CHAPTER IV SUMMARY OF FORECAST VERIFICATION

1. ANNUAL FORECAST VERIFICATION

a. Western North Pacific Area

Forecast positions at warning times and 24-, 48-, and 72-hour valid times were verified against corresponding best tracks. Vector errors and right angle errors for individual tropical cyclones were calculated and are displayed in Table 4-1. Annual mean errors for all tropical cyclones are listed in Table 4-2 for comparison. Frequency distributions of the vector errors for 24-, 48-, and 72-hour forecasts on all 1979 tropical cyclones are shown in Figure 4-1. Annual mean vector errors are graphed in Figure 4-2.

TABLE 4-1. FORECAST ERROR SUMMARY FOR THE 1979 WESTERN NORTH PACIFIC SIGNIFICANT TROPICAL CYCLONES.

CYCLONE	WARNING POSIT ERROR	WARNING RT ANGLE ERROR	WARNING # WRNGS	24 HOUR POSIT ERROR	24 HOUR RT ANGLE ERROR	24 HOUR # WRNGS	48 HOUR POSIT ERROR	48 HOUR RT ANGLE ERROR	48 HOUR # WRNGS	72 HR POSIT ERROR	72 HR RT ANGLE ERROR	72 HR # WRNGS
1. TY ALICE	18	11	51	105	83	47	222	175	43	338	271	39
2. TY BESS	19	15	21	114	73	17	265	164	13	348	240	9
3. TY CECIL	15	11	40	87	62	37	191	131	33	320	215	29
4. TS DOT	23	16	24	130	79	23	244	171	20	315	257	16
5. TD-05	12	12	6	158	150	3						
6. TY ELLIS	25	21	22	71	57	18	145	103	14	185	113	10
7. TS FAYE	35	21	20	138	86	17	167	93	14	180	99	10
8. TD-08	43	20	5	195	70	4	396	396	1			
9. TS GORDON	23	12	13	129	90	9	173	121	5	449	278	1
10. TS HOPE	23	16	33	134	75	29	266	140	23	376	188	21
11. TD-11	47	30	14	144	94	10	138	89	6	171	129	2
12. TY IRVING	26	17	38	163	98	34	286	209	30	441	344	26
13. ST JUDY	18	12	39	105	81	36	173	138	27	277	213	23
14. TD-14	33	19	9	157	43	5	296	118	1			
15. TS KEN	29	13	13	116	60	10	278	111	7	415	195	3
16. TY LOLA	16	10	23	88	64	21	172	148	19	287	236	14
17. TY MAC	23	16	35	93	66	27	196	152	19	279	227	19
18. TS NANCY	28	19	14	116	86	9	216	186	4	227	219	1
19. TY OWEN	25	15	37	146	78	33	250	158	29	327	256	25
20. TS PAMELA	28	22	6	254	15	2						
21. TS ROGER	32	19	16	195	93	13	251	108	9	303	178	4
22. TY SARAH	26	16	43	61	40	39	110	86	34	143	107	27
23. ST TIP	24	15	60	135	69	56	259	142	52	345	214	48
24. ST VERA	43	20	23	148	69	19	249	111	15	385	247	11
25. TS WAYNE	27	14	22	170	115	16	362	295	12	443	413	4
26. TY ABBY	31	17	52	164	108	48	286	198	39	338	215	26
27. TD-26	21	16	6	55	28	3						
28. TS BEN	34	18	10	81	89	6	287	16	2			
ALL FORECASTS	25	16	695	124	77	591	226	151	471	316	223	368

TABLE 4-2. ANNUAL MEAN FORECAST ERRORS FOR THE WESTERN NORTH PACIFIC.

	24-HR		48-HR		72-HR	
YEAR	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE
1971	111	64	212	118	317	177
1972	117	72	245	146	381	210
1973	108	74	197	134	253	162
1974	120	78	226	157	348	245
1975	138	84	288	181	450	290
1976	117	71	230	132	338	202
1977	148	83	283	157	407	228
1978	127	75	271	179	410	297
1979	124	77	226	151	316	223

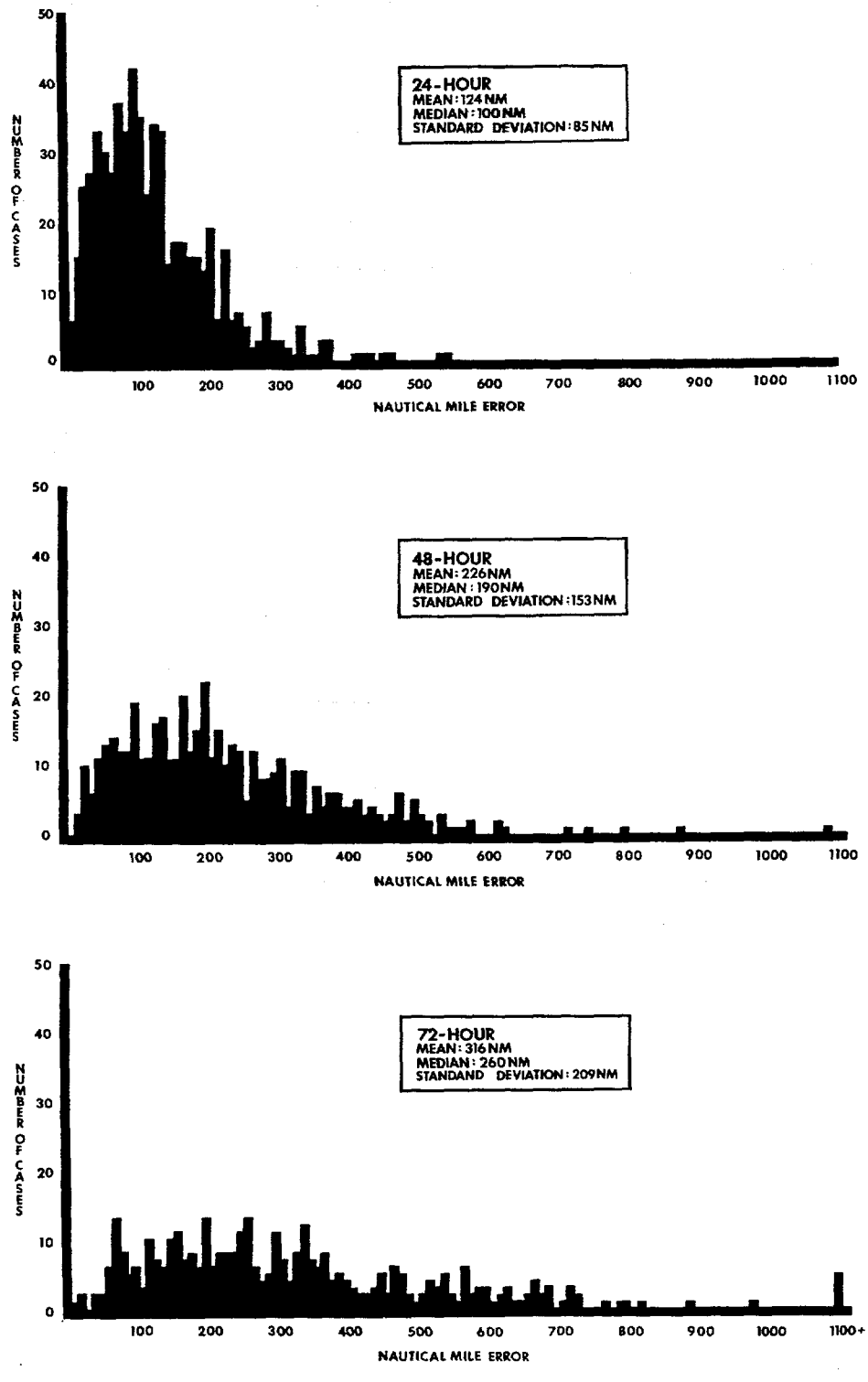


FIGURE 4-1. *Frequency distribution of 1979 24-, 48-, and 72-hour forecast vector errors for all significant tropical cyclones in the western North Pacific.*

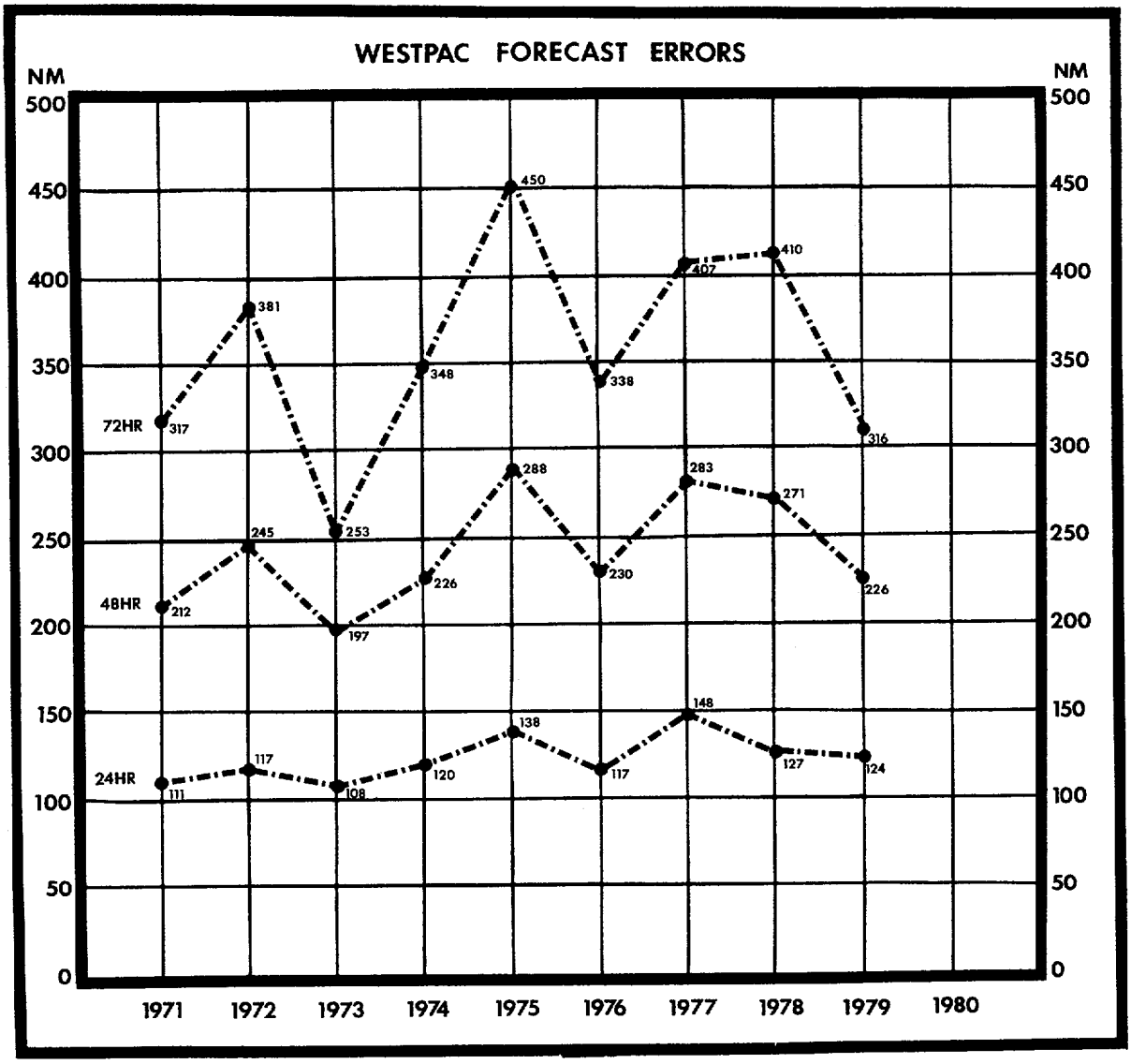


FIGURE 4-2. Annual vector errors (nm) for all cyclones in the western North Pacific.

Intensity verification statistics for all significant tropical cyclones in the western North Pacific area are depicted in Figures 4-3 and 4-4. The average absolute magnitude of the intensity error as well as the intensity bias (algebraic average) are graphically depicted. An analysis of the errors indicates that JTWC intensity forecasts often lag true intensity. In intensifying situations, JTWC underforecasts, while in weakening situations JTWC overforecasts. This causes a large average magnitude error, but a small average bias. Verification of intensity forecasts by objective aids is also depicted in Figures 4-3 and 4-4. (An explanation of the objective forecasting aids is found in this chapter, Section 2-Comparison of Objective Techniques.)

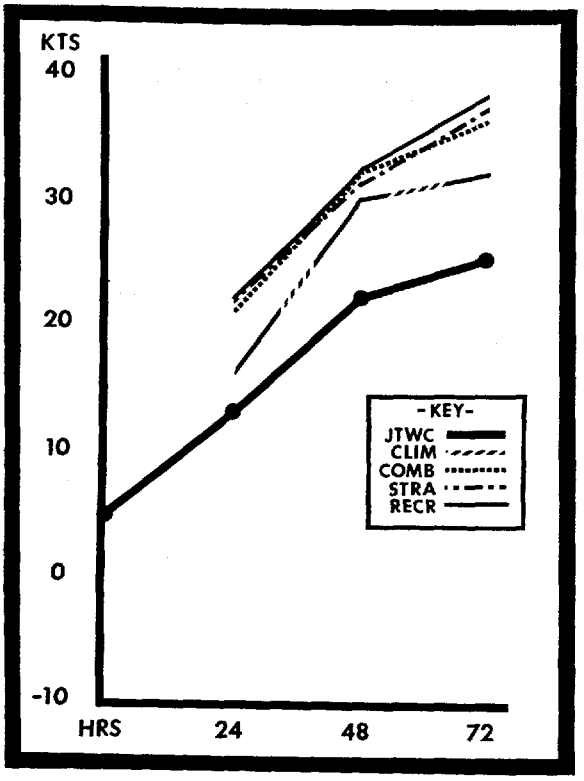


FIGURE 4-3. Comparison of average intensity errors (magnitude) for all cyclones in the western North Pacific.

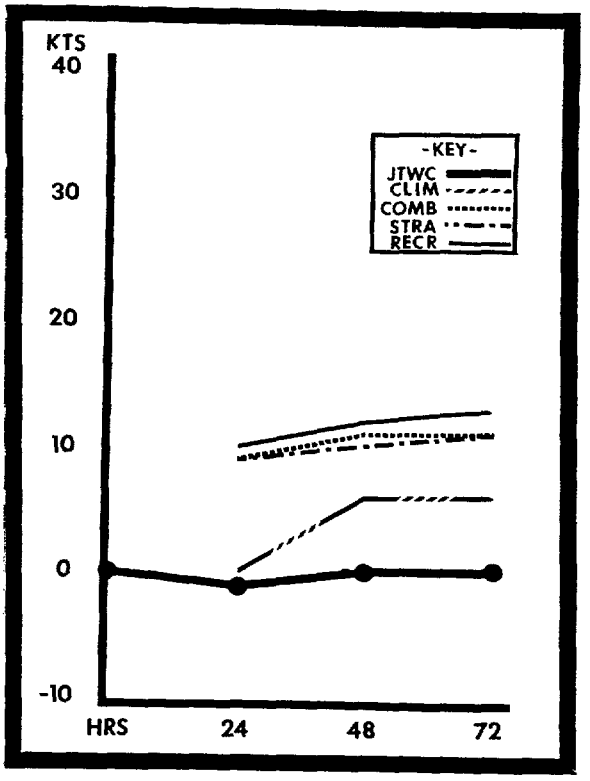


FIGURE 4-4. Comparison of average intensity errors (biases) for all cyclones in the western North Pacific.

b. North Indian Ocean Area

Forecast positions at Warning times and 24-, 48-, and 72-hour valid times were verified by the same methods used for the western North Pacific area. Table 4-3 is the forecast error summary for the significant tropical cyclones in the North Indian Ocean area. Table 4-4 contains the annual average of forecast errors back through 1971. Vector errors are plotted in Figure 4-5. Seventy-two hour forecast errors were evaluated for the first time in 1979.

Forecast intensities were not verified.

TABLE 4-3. FORECAST ERROR SUMMARY FOR THE 1979 NORTH INDIAN OCEAN SIGNIFICANT TROPICAL CYCLONES.

	WARNING			24 HOUR			48 HOUR			72 HOUR		
CYCLONE	POSIT ERROR	RT ANGLE ERROR	# WRNGS	POSIT ERROR	RT ANGLE ERROR	# WRNGS	POSIT ERROR	RT ANGLE ERROR	# WRNGS	POSIT ERROR	RT ANGLE ERROR	# WRNGS
TC 17-79	36	17	26	139	95	22	233	192	18	346	296	14
TC 18-79	48	24	12	137	78	7	363	284	4			
TC 22-79	54	34	10	122	90	7	170	122	3			
TC 23-79	48	21	14	160	97	9	253	184	5	773	629	2
TC 24-79	48	26	13	190	142	9	482	332	5	1036	902	1
TC 25-79	50	26	8	189	103	4	121	73	1			
TC 26-79	52	31	10	148	83	5	163	21	2			
ALL FORECASTS	46	24	93	151	99	63	270	202	38	437	371	17

TABLE 4-4. ANNUAL MEAN FORECAST ERRORS FOR THE NORTH INDIAN OCEAN (the Arabian Sea was not included prior to 1975).

	24-HR		48-HR		72-HR	
YEAR	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE	VECTOR	RIGHT ANGLE
1971	232	-	410	-	-	-
1972	224	101	292	112	-	-
1973	182	99	299	160	-	-
1974	137	81	238	146	-	-
1975	145	99	228	144	-	-
1976	138	108	204	159	-	-
1977	122	94	292	214	-	-
1978	133	86	202	128	-	-
1979	151	99	270	202	437	371

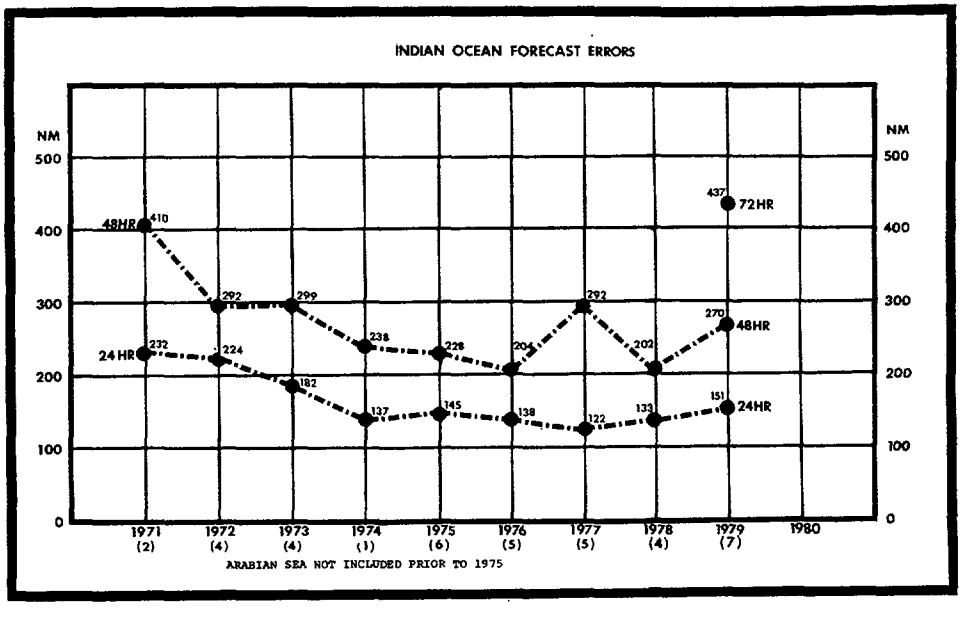


FIGURE 4-5. Annual mean vector errors (nm) for all cyclones in the North Indian Ocean.

2. COMPARISON OF OBJECTIVE TECHNIQUES

a. General

Objective techniques used by JTWC are divided into four main categories: (1) climatological and analog techniques; (2) extrapolation; (3) steering techniques; and (4) a dynamic model. The analog technique provides three movement forecasts: one for straight moving cyclones, one for recurving cyclones and one which combines the tracks of straight, recurving and cyclones that do not meet the criteria of straight or recurving analogs. All techniques were executed using the operational data available at warning time.

b. Description of Objective Techniques

(1) TYFN75 - Analog program which scans history tapes for cyclones similar (within a specified acceptance envelope) to the current cyclone. Three 24-, 48-, and 72-hour position and intensity forecasts are provided (straight, recurve and combined).

(2) MOHATT 700/500 - Steering program which advects a point vortex on a preselected analysis and smoothed prognostic field at designated levels in 6-hour time steps through 72 hours. Utilizing the previous 12-hour history position, MOHATT computes the 12-hour forecast error and applies a bias correction to the forecast position.

(3) TCM - The Tropical Cyclone Forecast model is a coarse mesh (220 km) PE Model, with the digitized storm warning position bogused in the 850 mb wind and temperature fields of the FLENUMOCEANCEN Global Band Analysis. Hemispheric forecast data are used on the boundaries.

(4) CLIM - A climatological aid in the form of 24-, 48-, and 72-hour tropical cyclone forecast positions and intensity changes for initial latitude/longitude positions. The data are arranged by months and are based on historical data which includes 1945 to 1973. This detailed climatology replaced the previous JTWC climatology on 1 September 1980.

(5) 12-HR EXTRAPOLATION - A track through the current warning position and the 12-hour old preliminary best track position is linearly extrapolated to 24 and 48 hours.

(6) HPAC - The 24- and 48-hour forecast positions are derived by averaging the 24- and 48-hour positions from the 12-hour EXTRAPOLATION track and the CLIM track.

(7) INJAH74 - Analog program for the North Indian Ocean similar to TYFN75, except tracks are not segregated.

(8) TYAN - An updated analog program which combines TYFN75 and INJAH74.

(9) CYCLOPS - An updated version of the MOHATT program which has the capability to select steering forecasts at the 1000, 850, 700, 500, 400, 300 and 200 mb levels.

c. Testing and Results

A comparison of selected techniques is included in Table 4-5 for all western North Pacific cyclones and in Table 4-6 for Indian Ocean cyclones. In Tables 4-5 and 4-6, "X-AXIS" refers to techniques listed horizontally across the top, while "Y-AXIS" refers to techniques listed vertically. The example in Table 4-5 compares COMB to MH70. In the 425 cases available for comparison, the average 24-hour vector error was 134 nm for COMB and 160 nm for MH70. The difference of 26 nm is shown in the lower right. (Differences are not always exact due to computational round off.)

TABLE 4-5.

STATISTICS FOR YEAR 24 HR FCSTS

	JTWC		STRA		RECR		COMB		MH70		MH50		TCMO		CLIM		XTRP		HPAC	
JTWC	591	124																		
	124	0																		
STRA	525	122	533	153																
	153	31	153	0																
RECR	516	127	489	153	524	139														
	139	12	136	-16	139	0														
COMB	543	124	514	153	509	139	551	135												
	135	10	133	-19	135	-3	135	0												
MH70	435	123	407	150	399	136	425	134	445	158										
	159	36	158	8	163	26	160	26	158	0										
MH50	425	124	396	152	389	136	413	135	430	159	434	157								
	158	35	157	5	160	25	159	24	157	-1	157	0								
TCMO	121	122	111	152	104	128	115	127	96	148	96	138	124	136						
	132	10	134	-16	146	18	141	14	143	-4	142	4	136	0						
CLIM	305	129	282	165	265	152	291	145	245	170	245	162	93	144	315	150				
	150	20	142	-22	150	-1	149	3	149	-20	150	-11	153	9	150	0				
XTRP	572	124	521	152	511	138	538	133	439	159	431	158	124	136	309	150	584	149		
	150	26	146	-5	153	15	150	17	145	-13	145	-12	142	6	168	18	149	0		
HPAC	559	124	514	152	501	137	527	133	434	158	426	158	124	136	309	150	571	150	571	134
	134	10	129	-23	135	-2	134	1	133	-24	132	-25	129	-6	138	-11	134	-15	134	0

NUMBER OF CASES | X-AXIS TECHNIQUE ERROR | Y-AXIS TECHNIQUE ERROR | ERROR DIFFERENCE Y-X

STATISTICS FOR YEAR 48 HR FCSTS

	JTWC		STRA		RECR		COMB		MH70		MH50		TCMO		CLIM		XTRP		HPAC	
JTWC	471	226																		
	226	0																		
STRA	437	224	462	306																
	309	85	306	0																
RECR	415	232	422	306	440	252														
	247	15	248	-57	252	0														
COMB	440	225	449	306	430	251	466	244												
	244	20	243	-62	243	-7	244	0												
MH70	330	222	340	307	323	249	347	243	359	308										
	313	91	308	1	318	69	310	67	308	0										
MH50	330	220	339	305	320	247	345	242	345	310	358	295								
	299	79	296	-8	297	50	297	55	292	-17	295	0								
TCMO	98	232	97	314	86	246	96	254	76	357	76	283	102	257						
	249	18	255	-57	273	27	264	10	264	-92	263	-20	257	0						
CLIM	244	235	249	330	222	276	247	265	205	337	206	294	75	272	263	250				
	246	11	243	-86	251	-25	252	-12	242	-94	242	-51	260	-11	250	0				
XTRP	457	224	450	304	430	249	454	241	351	309	353	296	101	255	260	249	485	291		
	291	67	290	-13	298	49	292	51	295	-13	291	-4	311	56	325	76	291	0		
HPAC	445	223	442	305	418	246	442	242	345	308	346	295	101	255	260	249	471	291	471	233
	232	9	231	-74	235	-10	233	-7	231	-75	228	-66	245	-9	235	-13	233	-57	233	0

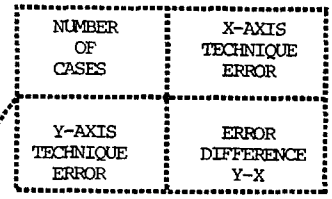
JTWC - OFFICIAL JTWC FORECAST
STRA - STRAIGHT (TYFN 75)
RECR - RECURVE (TYFN 75)
COMB - COMBINED (TYFN 75)
MH70 - MOHATT 700-MB PROG
MH50 - MOHATT 500-MB PROG
TCMO - TROPICAL CYCLONE MODEL (ONE-WAY)
CLIM - CLIMATOLOGY
XTRP - 12-HOUR EXTRAPOLATION
HPAC - MEAN OF XTRP AND CLIMATOLOGY

STATISTICS FOR YEAR 72 HR FCSTS

	JTWC		STRA		RECR		COMB		MH70		MH50		TCMO		CLIM	
JTWC	368	316														
	316	0														
STRA	338	315	381	453												
	443	129	453	0												
RECR	319	331	345	456	360	349										
	327	-3	348	-107	349	0										
COMB	343	316	370	452	352	349	385	340								
	328	12	343	-109	336	-12	340	0								
MH70	230	325	260	464	236	362	259	352	267	473						
	471	147	474	10	488	126	475	122	473	0						
MH50	227	329	258	467	234	364	257	355	259	469	265	486				
	482	153	481	14	488	124	482	127	479	10	486	0				
TCMO	73	314	78	445	69	351	78	359	61	543	62	484	84	372		
	347	33	376	-68	393	41	380	22	401	-141	396	-87	372	0		
CLIM	184	308	208	494	179	357	204	366	161	506	164	483	64	389	218	332
	315	7	333	-160	338	-18	334	-31	329	-176	331	-151	353	-34	332	0

STATISTICS FOR YEAR 24 HR FCSTS

	JTWC		INJA		MH70		MH50		TCMO		XTRP		HPAC	
JTWC	63	151												
	151	0												
INJA	48	134	52	127										
	125	-7	127	0										
MH70	28	159	27	132	30	180								
	173	14	175	44	180	0								
MH50	27	158	26	132	29	175	29	173						
	167	9	164	32	173	-1	173	0						
TCMO	2	43	2	53	2	73	2	64	2	164				
	164	121	164	111	164	91	164	100	164	0				
XTRP	61	147	52	127	30	180	29	173	2	164	65	148		
	146	0	130	3	148	-32	149	-23	14	-150	148	0		
HPAC	40	148	32	134	16	179	15	175	2	164	40	145	40	135
	135	-12	128	-5	146	-31	148	-26	43	-120	135	-9	135	0



STATISTICS FOR YEAR 48 HR FCSTS

	JTWC		INJA		MH70		MH50		TCMO		XTRP		HPAC	
JTWC	38	270												
	270	0												
INJA	26	252	26	227										
	227	-24	227	0										
MH70	14	332	9	273	15	340								
	360	28	365	91	340	0								
MH50	13	338	8	298	14	331	14	388						
	407	69	447	149	388	57	388	0						
TCMO	0	0	0	0	1	61	1	141	1	343				
	0	0	0	0	343	282	343	202	343	0				
XTRP	36	272	25	235	15	340	14	388	1	343	37	255		
	259	-12	243	8	243	-96	252	-135	110	-232	255	0		
HPAC	23	270	18	235	8	310	7	424	1	343	24	269	24	225
	231	-38	224	-11	233	-76	249	-174	86	-256	225	-43	225	0

JTWC - OFFICIAL JTWC FORECAST
INJA - ANALOG (INJAH74)
MH70 - MOHATT 700-MB PROG
MH50 - MOHATT 500-MB PROG
XTRP - 12-HOUR EXTRAPOLATION
HPAC - MEAN OF XTRP AND CLIMATOLOGY

STATISTICS FOR YEAR 72 HR FCSTS

	JTWC		INJA		MH70		MH50	
JTWC	17	437						
	437	0						
INJA	12	350	12	292				
	262	-57	292	0				
MH70	2	876	1	361	2	460		
	460	-415	263	-97	460	0		
MH50	2	876	1	361	2	460	2	838
	838	-37	1033	672	838	378	838	0

TABLE 4-6.